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DCL 60-11-76

This document consists of 7 pag[redacted]

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Doc. No. DCL 60-11-76

AIRCRAFT NUCLEAR PROPULSION DEPARTMENT

MASTER

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ESTIMATED PERFORMANCE OF SUPERSONIC NUCLEAR AIRCRAFT WITH SIX PRATT AND WHITNEY INDIRECT CYCLE J-58 TURBOJET ENGINES

E. M. Nash

APPLICATIONS TECHNICAL ANALYSIS

November 3, 1960

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D. F. SHAW

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Chief, Declassification Branch

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Serial No. 16276

GENERAL ELECTRIC UNCLASSIFIED

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November 3, 1960

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APPLICATIONS TECHNICAL ANALYSIS

An estimated performance analysis of an aircraft powered with six Pratt & Whitney J-58 engines with one indirect cycle nuclear reactor has been completed. The total weight of the power plants plus crew shield was given as 227,000 pounds by Product Planning. Other component weights were estimated. Two different supersonic power conditions and the subsonic L/D ratio and specific fuel consumption were also given. These are tabulated as follows:

Power Condition	Mission Phase	Mach Number	L/D	Altitude Feet	Thrust Pounds	Specific Fuel Consumption
A	Sprint	3.0	----	65,000	62,400	1.41
B	Sprint	3.0	----	65,000	82,200*	1.70*
C	Cruise	0.9	12	35,000	----	1.00

The weight breakdowns of two airplanes operating at power conditions "A" and "B" as shown above are included in Table I. The takeoff weights shown represent the minimum that may be expected, compatible with these powers, as they do not include any specific allowance for subsonic cruise after sprint. At the lower gross weight, the 10,000 pounds of reserve fuel provides for only 140 nautical miles of cruise after sprint. However, there does exist an emergency cruise capability that may be employed in place of sprint. This is based upon the utilization of the climb, sprint, and reserve fuel allowances. With the utilization of this fuel, the 518,000 pound airplane will cruise subsonically 990 nautical miles, and the 562,000 pound airplane will cruise 1,300 nautical miles.

Assuming various takeoff gross weights, and with power condition "A" during sprint, the amount of fuel available for subsonic emergency cruise after sprint and the corresponding mileages have been computed. The results of the analysis for this power condition are as follows:

* Maximum afterburning condition

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Takeoff Gross Weight Pounds	Fuel Available* For Cruise After Sprint Pounds	Emergency Cruise Range After Sprint Nautical Miles	L/D Required For Sprint
518,000	10,000	140	7.65
600,000	66,800	830	8.96
640,000	93,800	1,110	9.60
655,000	104,000	1,210	9.85

As indicated in the above table, the L/D values required during sprint for all weights above 518,000 pounds are higher than those presently attainable. In addition, the required takeoff weights are high. Hence, the conclusion may be made that no appreciable subsonic emergency range may be attained after sprint, when sprint is made at the modulated afterburning condition, power condition "A", previously referred to.

A similar analysis based upon the utilization of power condition "B", maximum afterburning, yields the following results:

Takeoff Gross Weight Pounds	Fuel Available* For Cruise After Sprint Pounds	Emergency Cruise Range After Sprint Nautical Miles	L/D Required For Sprint
562,000	10,000	135	6.16
591,000	30,000	390	6.52
620,000	50,000	622	6.86
649,000	70,000	840	7.22
677,000	90,000	1,040	7.57

The above tabulated results indicate that the required L/D values during sprint with maximum afterburning are within the present realm of possible attainment, but again, as with modulated afterburning, the required takeoff gross weights are excessively high.

A further analysis was made to determine the difference in takeoff gross weight between a one-reactor and a two-reactor type of airplane. Fuel for subsonic emergency cruise after sprint was included for the one-reactor airplane only. Since this fuel has to be carried during the supersonic sprint, the average gross weight and the thrust required are higher. This results in a greater amount of required sprint fuel for the one-reactor type of airplane. Both types of airplanes were assumed to fly at a sprint L/D value of 7.5. The afterburning power levels are between those previously referred to as power conditions "A" and "B".

The weight breakdowns for both the one-reactor and two-reactor types of airplanes are included in Table II. With the 60,000 pounds of fuel assumed for the one-reactor type of airplane, the subsonic emergency cruise range is 730 nautical miles. No fuel was allowed for this purpose for the two-reactor type of airplane, because of the small probability of both reactors malfunctioning at the same time.

* Includes 10,000 pounds reserve fuel

In conclusion, the results of the analysis indicate that the one-reactor type of airplane requires high takeoff gross weights if emergency cruise fuel is to be included. A very substantial takeoff weight saving may be realized, however, with the two-reactor type of airplane, provided that the two-reactor type aircraft is technically feasible with the Pratt & Whitney indirect cycle.

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APPLICATIONS TECHNICAL ANALYSIS

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TABLE I
WEIGHT BREAKDOWN OF NUCLEAR AIRCRAFT WITH
ONE REACTOR AND SIX PRATT & WHITNEY J58 ENGINES

	Weight, Pounds	
	Power Condition "A"	Power Condition "B"
Six Power Plants Plus Crew Shield	227,000	227,000
Equipment	30,000	30,000
Payload	20,000	20,000
Useful Load	4,000	4,000
Estimated Fuel for Climb and Acceleration	15,000	15,000
Fuel for Sprint 1,000 Nautical Miles at M = 3.0 at 65,000 Ft	51,200	81,300
Reserve Fuel	10,000	10,000
Sub-Totals	357,200	387,300
Structure	160,800	174,700
Takeoff Gross Weight	518,000	562,000
Thrust During Sprint, Pounds	62,400	82,200
Sprint Average Gross Weight	477,400	506,350
Sprint L/D Required	7.65	6.16

TABLE II
WEIGHT BREAKDOWN OF NUCLEAR AIRCRAFT
WITH SIX PRATT & WHITNEY J58 ENGINES

	Weight, Pounds	
	One Reactor	Two Reactors
Six Power Plants Plus Crew Shield	227,000	252,000
Equipment	30,000	30,000
Payload	20,000	20,000
Useful Load	4,000	4,000
Estimated Fuel for Climb and Acceleration	15,000	15,000
Fuel for Sprint 1,000 Nautical Miles at M = 3.0 at 65,000 Ft	75,000	60,000
Fuel for Emergency Subsonic Cruise 730 Nautical Miles at M = 0.9 at 35,000 Ft After Completion of Sprint	60,000	---
Reserve Fuel	10,000	10,000
Sub-Totals	441,000	391,000
Structure	199,000	176,000
Takeoff Gross Weight	640,000	567,000
Thrust During Sprint, Pounds	77,200	69,500
Sprint Average Gross Weight	577,500	521,000
Sprint L/D Required	7.5	7.5